

# Electrical Systems and Troubleshooting

# Terminal Learning Objective

- Provided an item of engineer equipment with a malfunctioning electrical system, necessary tools, and the appropriate technical manuals, repair the electrical system so that it functions properly I.A.W. the appropriate technical manual.

# Enabling Learning Objectives

- Provided with a schematic of an electrical system, identify the symbols on the schematic
- Provided with a multimeter and a conductor, determine if the conductor has continuity

# Enabling Learning Objectives

- Provided a multimeter and an electrical system, measure system current, voltage and resistance
- Provided with an electrical schematic identify and explain the various types of electrical circuits
- Provided with an electrical schematic, an item of engineer equipment, describe the four basic types of electrical failure.

# Enabling Learning Objectives

- Provided with an electronic circuit, and using ohm's law , determine resistance in a circuit
- Provided with a circuit breaker or fuse, appropriate test equipment, determine if the circuit breaker or fuse is serviceable
- Provided with a switch or relay, appropriate test equipment, determine if the switch or relay is serviceable

# Enabling Learning Objectives

- Provided with a resistor or capacitor, appropriate test equipment, determine if the resistor or capacitor is serviceable
- Provided with a solenoid or transformer, appropriate test equipment, determine if the solenoid or transformer is serviceable
- Provided with a diode or transistor, appropriate test equipment, determine if the diode or transistor is serviceable

# Enabling Learning Objectives

- Provided with a starter, appropriate test equipment, determine if the starter is serviceable
- Provided with an alternator, appropriate test equipment, determine if the alternator needs adjustment, and adjust the alternator if necessary to specification.

# Student Reading Assignments

- FOS Electrical Systems  
chapters 1-9, 11 and 12

FOS Electronic and Electrical  
Systems  
chapters 1-10, 12





# What is electricity?

- Flow of electrons from atom to atom through a conductor
- Atoms which have less than four electrons in their outer rings are good conductors of electricity



# Conductors and Insulators

- A conductor is an element whose atom have less than four electrons in their outer ring
- An insulator is an element whose atom have more than four electrons in their outer rings



# Current

- Current is the flow of electrons through a conductor (wire)
- Current is measured in amperes
- Current in amperes, or rate of flow of electrons, is similar to the flow of water in a pipe



# Voltage

- Voltage is the force that causes the flow of current in a conductor
- Voltage, also referred to as pressure or potential, is measured in volts
- Voltage is the same as pressure in a pipe that causes water to flow through the pipe.



# Resistance

- The property of a conductor that opposes the passage of an electrical current and changes electrical energy to heat
- All conductors offer some resistance to the flow of current
- Resistance is measured in ohm's



# Resistance in a Circuit

- Sometimes its an advantage
- Sometimes a disadvantage
- Resistance is due to:
  - Length of wire
  - Cross sectional area of wire
  - Temperature of wire

# TMDE

- Current is measured with an ammeter
- Voltage is measured with a voltmeter
- Resistance is measured with an ohmmeter
- All three gauges can be combined into a multimeter



# Electromagnetism

- Electricity and magnetism are related because a magnetic field is established around a conductor that is carrying current
- Right hand rule states that if you grasp a wire with your thumb extended in the direction of conventional current flow, the fingers will then point in the direction in which the lines of force surround the conductor

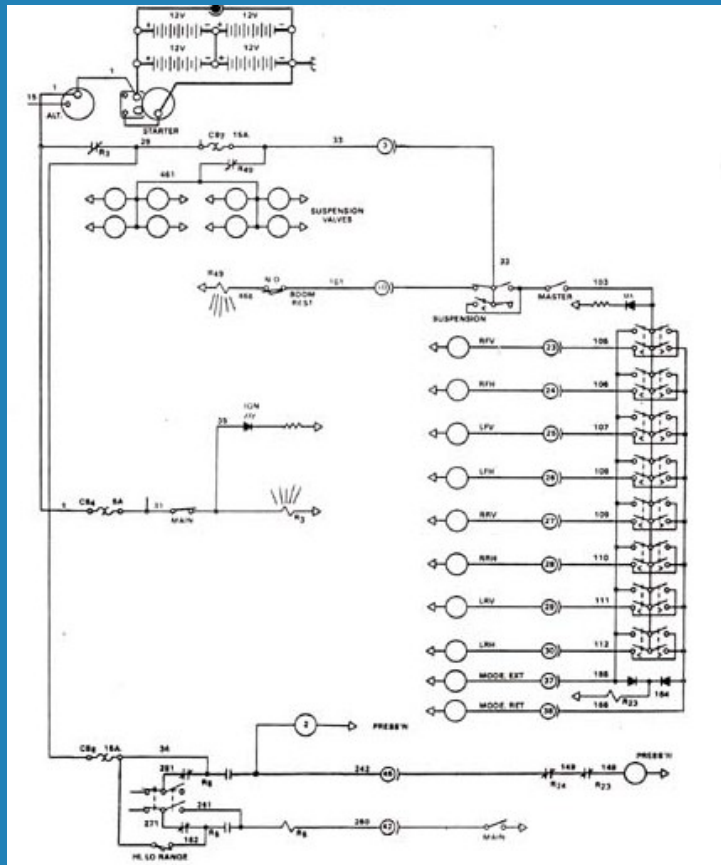




# Electromagnetic induction

- Is when a conductor is moved across a magnetic field, and a voltage is induced in the conductor
- It takes voltage to create voltage
- Generated Voltage- one form of electromagnetic induction used in alternators and generators

# Electrical Circuits



- An electrical circuit is a schematic of electronic components that permit the flow of electrons



# Types of Electrical Circuits

- Series- several resistors connected together so that current flows along one path. (High Resistance)
- Parallel- More than one path for the current to flow. Resistors are side-by-side and provide separate routes for current. (low resistance)
- Combination Series/Parallel- some resistors connected in series and some in parallel (medium resistance)



# Pulse, Waves, Frequency

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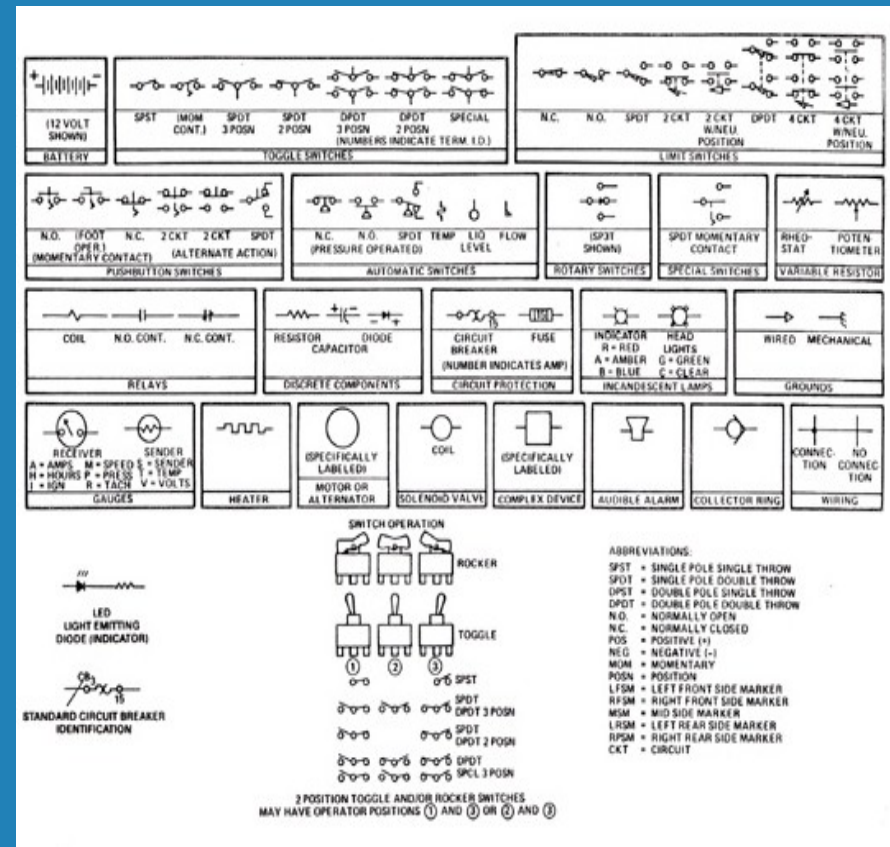
- Pulse- A sudden on and off of direct current flow within a circuit
- Wave- created by varying a continuous flow of electrons within a circuit
- Frequency- the number of cycles occurring in one unit of time, generally one second

# Common Electrical Failures

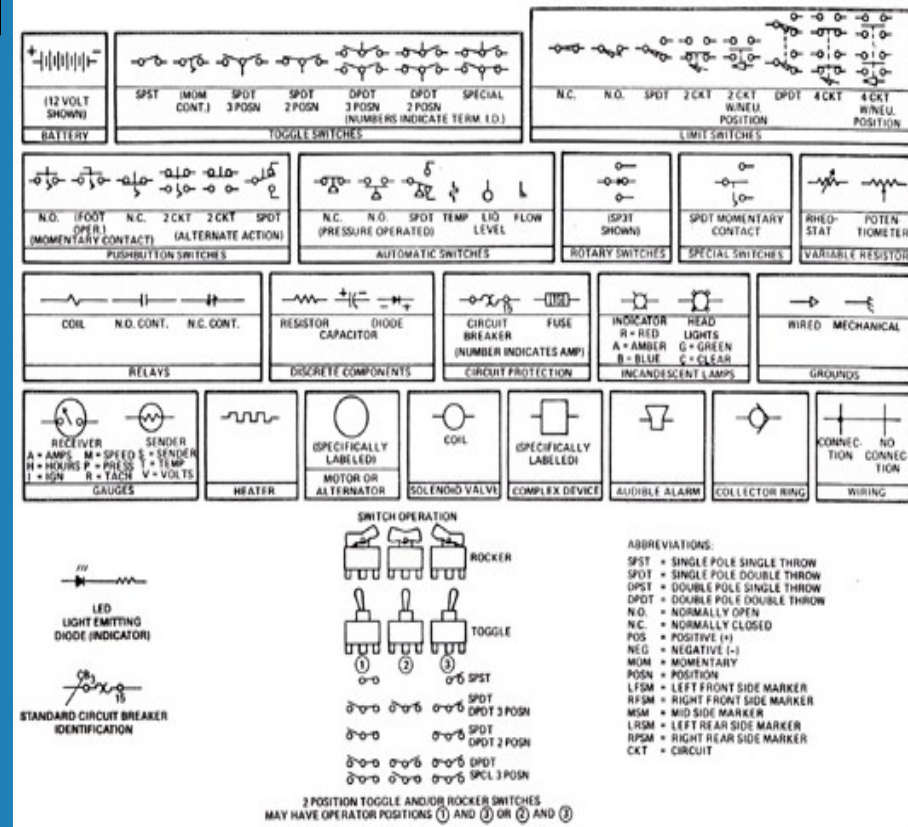
- High Resistance
- Open
- Ground
- Short

# Five Electrical Schematics and Diagrams

- System functional schematic
- Subsystem functional schematic
- System wiring diagram
- Component location drawing
- Subsystem diagnostic schematic



- Wire numbers and color codes
- Standards used for diagrams and schematics
  - International
  - S.A.E.



# Conductors

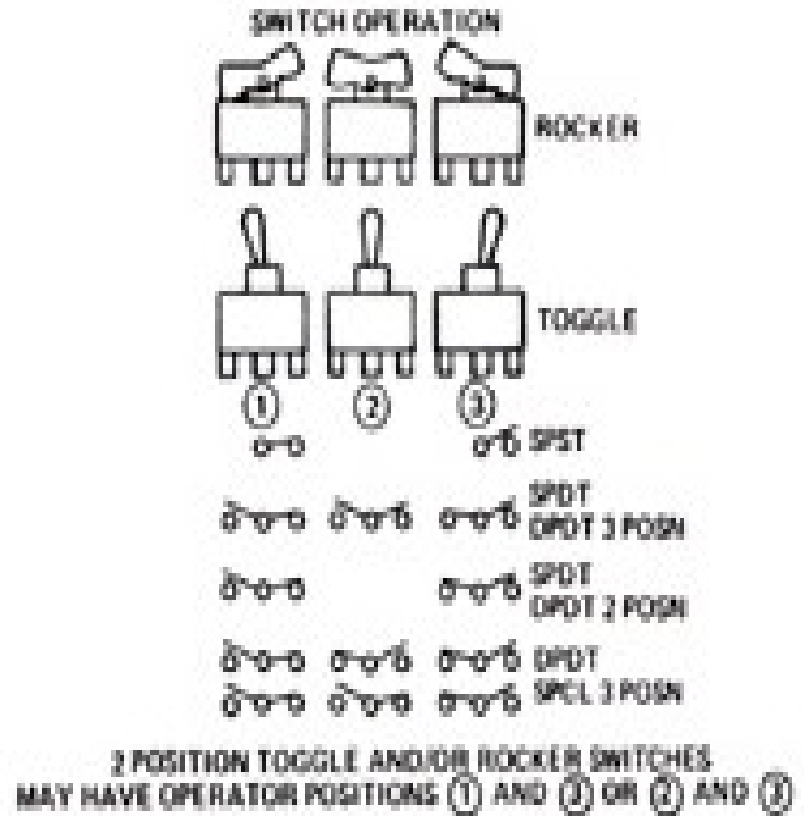
- Copper is most common because of availability and cost
- Copper tends to withstand more heat and has a lower failure rate than other metals





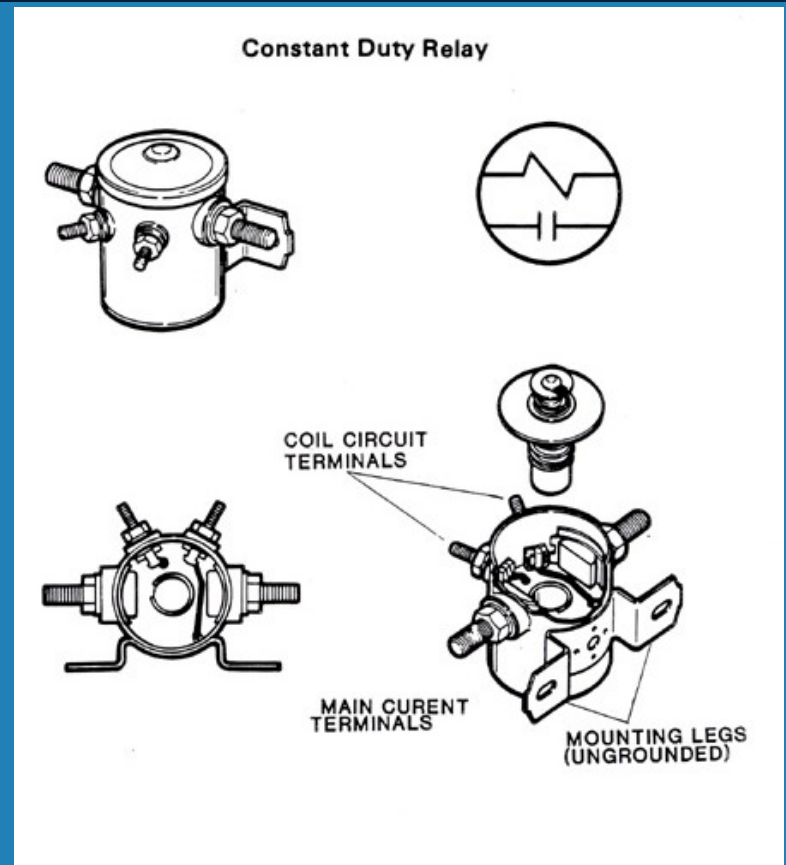
# Switches

- Device that open and close the flow of electrons in a circuit
- Three ways a switch may be activated-mechanically, pressure, magnetically



# Relays

- Are electrically controlled switches that allow a small current to control a larger current
- One of the most common is a starter relay



# Resistors

- It reduces voltage output by resisting current flow in a circuit
- Temperature and humidity must be considered when using them
- Two types- Fixed and Variable type



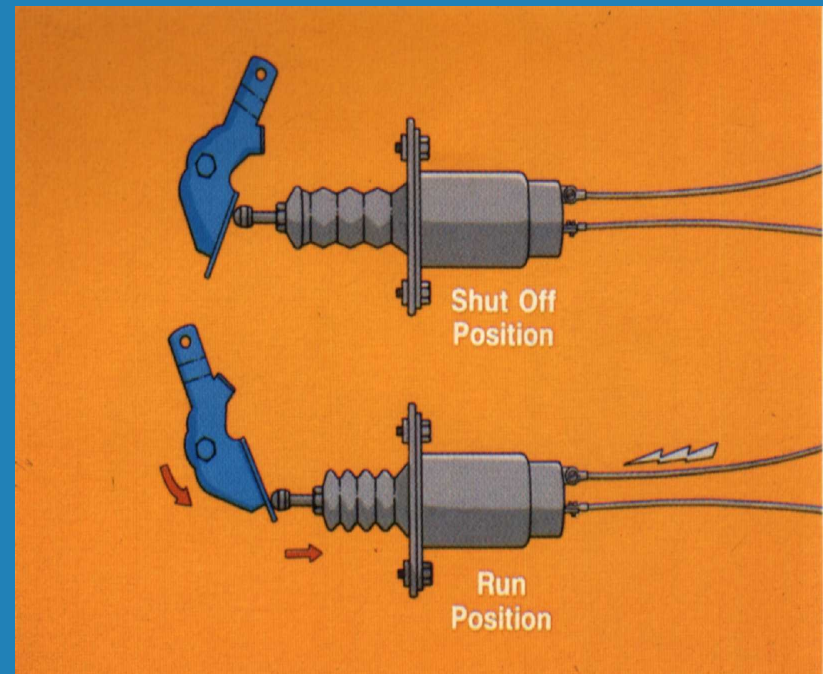


# Capacitors

- Smooth out changing voltage to a more constant voltage
- Trap or temporarily store electrical energy that could damage electrical components

# Solenoids

- Device that use the strength of a magnetic field generated in a coil to move a metal core
- The moving core along with linkage can transfer its motion to other mechanical devices



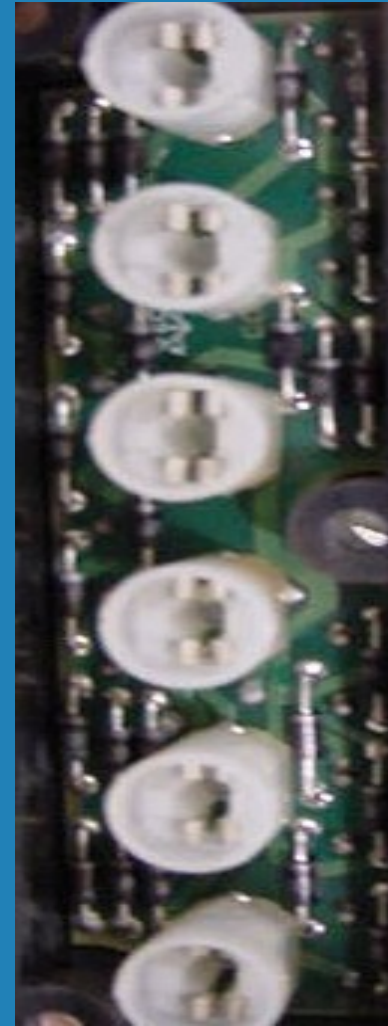
# Diodes

- A device that will only allow current to flow one way
- Commonly used in charging circuits to prohibit the discharge of the battery



# Integrated Circuits

- Is a device that contains circuits composed of resistors, diodes, transistors and capacitors or any other electronic component
- Sometimes referred to as a chip because of small size



# Common types of I/C

- Analog I/C- amplify or or respond to variable voltages
- Digital I/C- composed of circuits that produce voltage signals or pulses that have only two levels, on or off



# DISPLAY DEVICES

- Analog Gauges- most common, operates by a varying signal that causes a mechanical change in the position of a needle
- Light Emitting Diodes- solid state display device that is self illuminating.
- Liquid Crystal Display- Shows data output from integrated circuits.



# Magnetic Pickup

- Use the motion of a magnetic field past a coil or the motion of metal past a magnetic field to generate a signal.
- Commonly used as tachometer pickups.
- Embeds a small magnet in the flywheel.



# Fuses and Circuit Breakers

- Used to protect the circuit, conductors, and components from overload.
- Fuses must be replaced when blown
- Circuit Breakers can be reset manually or automatically when tripped.

# BATTERIES

- Has three main functions
  1. Supply starting power
  2. Supply current when demand exceeds the output of the starting engine.
  3. Supply stability to the electrical system.



# Battery Components

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- Cells
- Electrolyte
- Plates
- Post
- Cover
- Vent cap



# Battery Plates

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- Negative Plate- contains spongy lead and is gray in color.
- Positive Plate- contains lead peroxide and is chocolate brown in color.



# Cell Voltage

- Each cell has two volt potential
- 6 volt battery has three cells connected in series
- 12 volt battery has six cells connected in series



# Producing Current

- A chemical reaction takes place between the unlike plates
- Sulfuric acid acts as the medium for current flow.
- When chemical reaction occurs, battery is discharging
- Battery solution is 36% sulfuric acid, 64% water,





# Battery Life

- Constructed to last 48 months under normal usage
- Military batteries on average last six months.